

## **How to Talk to Computers**

### **Introduction to QFN - 48 package, chip, pads, core, die and IPs**

- ❖ SoC – System on a chip (layman's term is “CHIP” but technically is a “PACKAGE” – example of package used in arduino is a QFN - 48 (quad flat no -leads)
- ❖ Chip components – **pads** (connecters between IC and chips, structures for sending electrical signals within chips), **core** (digital logic, carries out processor functions), **die** (contains more than one core).
- ❖ Core can be mostly segregated into foundry IPs and macros (pure digital logic).

### **Introduction to RISC V**

- ❖ RISC-V Instruction Set Architecture (RISC V ISA) is the language of the computer (assembly language program)

### **From Software Applications to Hardware**

- ❖ System software – **OS** (I.O operation, memory allocation, low level system function - produce in C or Java etc. to send to compiler), **Compilers** (simple instructions in .exe documents that are sent to assemblers, interface of instructions are called ISAs), **assemblers** (convert info from compilers to binary)

## **SoC Design and OpenLANE**

### **Introduction to Components of Opensource Digital ASIC Design**

- ❖ ASICs require mainly three components to design – **RTL IPs** (building blocks written in HDL, describe circuit at a basic level and are predesigned/verified), **EDA Tools** (used for design, simulation, verification, and analysis of circuit designs), **PDK data** (Process Design Kit data - collection of files to model fabrication process, includes Process Design Rules, Device Models, Digital Standard Cell Libraries and IO libraries)

### **Simplified RTL to GDS flow**

- ❖ RTL to GDSII is Register Transfer Level to Graphic Design System II
- ❖ Steps for above are: **synthesis** (converts HDLs like verilog into gate-level representations from parts of a standard cell library(SCL)), **floor and power planning** (optimizing chip performance, area, and connectivity through the layout of components - main purposes are minimizing wire length, reducing signal delay, optimizing power distribution —> Power planning: minimize voltage drop and

noise, reduce PDN resistances and capacitance, uniform power distribution), **placement** (usually placed on floorplan rows and aligned w/ sites: 2 major steps - global and detailed), **clock tree synthesis** (done before routing, deliver clock to all sequential elements w/ min skew (zero is hard to get), usually tree), **routing** (implement the interconnect through multiple metal layers), **sign off** (verification through three processes: **design rule check** (DRC) – makes sure design compiles w/ manufacturing guidelines and is compatible for fabrication, **aims to correct layout errors**, **layout vs schematic** (LVS) – layout contrasted w/ schematic for consistency, **static timing analysis** (STA) – eval timing to ensure design meets setup and hold time constraints, max clock freq, etc.

### **Introduction to OpenLANE and Strive Chipsets**

- ❖ OpenLane is open-source digital ASIC – aims to create a clean GDII

#### **Introduction to OpenLANE detailed ASIC Design Flow**

- ❖ **Synthesis exploration** – creates delay vs area report
- ❖ **Design exploration** – sweeps design config to generate the best config for a design and makes a report
- ❖ OpenLANE Regression Testing
- ❖ **Design for Test** (DFT) – scan insertion, automatic test pattern generation, test patterns compaction, fault coverage, fault simulation
- ❖ **Physical Verification** – magic for drc and magic/netgen for LVS
- ❖ **Logic Equivalence Check** (LEC) - checks physical implement and netlist have same logic
- ❖ **Timing Analysis** (STA) - input contains synthesized netlist + other data

## **Get familiar to open-source EDA tools**

### **OpenLANE Directory structure in detail**

- ❖ cd : change directory (cd.. goes back a directory)
- ❖ ls : list items in directory
- ❖ ls -ltr : how list of items should be ordered (ls –help for help)
- ❖ ~/Desktop/work/tools : where all OpenLANE files are stored

```
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/openlane
drwxr-xr-x 2 beaver beaver 4096 Jun 27 2021 gds
drwxr-xr-x 2 beaver beaver 4096 Jun 27 2021 doc
drwxr-xr-x 2 beaver beaver 4096 Jun 27 2021 cdl
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd$ cd lef
beaver@openlanenvm:~/Desktop/work/tools/openLane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd/lef$ ls -ltr
total 2212
-rw xr-xr-x 1 beaver beaver 1822 Jun 27 2021 sky130_ef_sc_hd_fill_12.lef
-rw xr-xr-x 1 beaver beaver 1453 Jun 27 2021 sky130_ef_sc_hd_fakediode_2.lef
-rw xr-xr-x 1 beaver beaver 1947 Jun 27 2021 sky130_ef_sc_hd_decap_12.lef
-rw xr-xr-x 1 beaver beaver 2252747 Jun 27 2021 sky130_fd_sc_hd.lef
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd/lef$ cd ..
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd$ cd techlef/
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd/techlef$ ls -ltr
total 20
-rw xr-xr-x 1 beaver beaver 18007 Jun 27 2021 sky130_fd_sc_hd.tlef
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A/libs.ref/sky130_fd_sc_hd/techlef$ cd ../../..
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/pdkss/sky130A$ cd ../..
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir$ ls -ltr
total 16
drwxr-xr-x 5 beaver beaver 4096 Jun 27 2021 pdkss
drwxr-xr-x 10 beaver beaver 4096 Jun 28 2021 openlane_old
drwxrwxr-x 9 beaver beaver 4096 Jul 13 19:52 openlane2
drwxr-xr-x 15 beaver beaver 4096 Jul 14 07:40 openlane
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir$ cd openlane
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/openlane$
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs$ cd ci
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd picorv32a/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ ls -ltr
total 12
drwxrwxr-x 2 beaver beaver 4096 Jul 15 16:44 src
-rw-rw-r-- 1 beaver beaver 487 Jul 15 16:44 config.json
drwxr-xr-x 6 root root 4096 Jul 15 17:45 runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ ls
drwxr-xr-x 13 openlane-user 1000 1000 4096 Jul 14 14:34 scripts
drwxr-xr-x 23 openlane-user 1000 1000 4096 Jul 14 14:34 tests
drwxr-xr-x 2 root root 4096 Jul 14 14:35 empty
drwxrwxr-x 5 openlane-user 1000 1000 4096 Jul 14 14:35 dependencies
drwxr-xr-x 5 root root 4096 Jul 14 14:38 venv
drwxr-xr-x 2 root root 4096 Jul 14 14:40 install
% cd docs
% cd ..
% cd designs
% ls -ltr
total 8
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ ls -ltr
total 12
drwxrwxr-x 2 beaver beaver 4096 Jul 15 16:44 src
-rw-rw-r-- 1 beaver beaver 487 Jul 15 16:44 config.json
drwxr-xr-x 6 root root 4096 Jul 15 17:45 runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd ci/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ ls -ltr
total 8
drwxrwxr-x 3 openlane-user-1000 1000 4696 Jul 14 14:34 flowdocs
drwxrwxr-x 27 openlane-user-1000 1000 4096 Jul 15 23:44 ci
% cd designs
couldn't change working directory to "designs": no such file or directory
%
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs
/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd ci
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd picrv32a/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picrv32a$ ls -ltr
total 12
drwxrwxr-x 2 beaver beaver 4096 Jul 15 16:44 src
-rw-rw-r-- 1 beaver beaver 487 Jul 15 16:44 config.json
drwxr-xr-x 6 root root 4096 Jul 15 17:45 runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picrv32a$ ls
src config.json runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picrv32a$ cd src
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picrv32a$ ls
flowdocs install
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picrv32a$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ ls -ltr
total 8
drwxrwxr-x 3 openlane-user-1000 1000 4696 Jul 14 14:34 flowdocs
drwxrwxr-x 27 openlane-user-1000 1000 4096 Jul 15 23:44 ci
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs$ cd RUN_2025.07.16_00.45.26
bash: cd: RUN_2025.07.16_00.45.26: No such file or directory
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs$ cd RUN_2025.07.16_00.45.26
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ ls -ltr
total 64
-rw-r--r-- 1 root root    51 Jul 14 07:39 PDK_SOURCES
-rw-r--r-- 1 root root   674 Jul 15 17:45 config_in.tcl
drwxr-xr-x 8 root root 4096 Jul 15 17:45 reports
drwxr-xr-x 8 root root 4096 Jul 15 17:45 results
drwxr-xr-x 8 root root 4096 Jul 15 17:45 logs
drwxr-xr-x 8 root root 4096 Jul 15 17:45 tmp
-rw-r--r-- 1 root root     50 Jul 15 17:45 OPENLANE_VERSION
-rw-r--r-- 1 root root 18605 Jul 15 17:45 config.tcl
-rw-r--r-- 1 root root  3703 Jul 15 17:45 cmd.log
-rw-r--r-- 1 root root   525 Jul 15 17:45 openlane.log
-rw-r--r-- 1 root root   254 Jul 15 17:45 warnings.log
-rw-r--r-- 1 root root    79 Jul 15 17:45 runtime.yaml
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ 
[1] couldn't change working directory to "designs": no such file or directory
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ cd tmp
drwxr-xr-x 8 root root 4096 Jul 15 17:45 tmp
-rw-r--r-- 1 root root    50 Jul 15 17:45 OPENLANE_VERSION
-rw-r--r-- 1 root root 18605 Jul 15 17:45 config.tcl
-rw-r--r-- 1 root root  3703 Jul 15 17:45 cmd.log
-rw-r--r-- 1 root root   525 Jul 15 17:45 openlane.log
-rw-r--r-- 1 root root   254 Jul 15 17:45 warnings.log
-rw-r--r-- 1 root root    79 Jul 15 17:45 runtime.yaml
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ cd tmp
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/tmp$ ls -ltr
total 4224
drwxr-xr-x 2 root root 4096 Jul 15 17:45 placement
drwxr-xr-x 2 root root 4096 Jul 15 17:45 floorplan
drwxr-xr-x 2 root root 4096 Jul 15 17:45 signoff
-rw-r--r-- 1 root root    28 Jul 15 17:45 layers.list
-rw-r--r-- 1 root root 1429507 Jul 15 17:45 merged.nom.lef
-rw-r--r-- 1 root root 1429503 Jul 15 17:45 merged.min.lef
-rw-r--r-- 1 root root 1429506 Jul 15 17:45 merged.max.lef
drwxr-xr-x 2 root root 4096 Jul 15 17:45 synthesis
drwxr-xr-x 2 root root 4096 Jul 15 17:45 cts
drwxr-xr-x 2 root root 4096 Jul 15 17:45 routing
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/tmp$ 
[1] couldn't change working directory to "designs": no such file or directory
```

OpenLane Launcher - OpenLane2 Launcher - work

%

Get out of this

```
-rw-r--r-- 1 root root 18605 Jul 15 17:45 config.tcl
-rw-r--r-- 1 root root 3703 Jul 15 17:45 cmd.log
-rw-r--r-- 1 root root 525 Jul 15 17:45 openlane.log
-rw-r--r-- 1 root root 254 Jul 15 17:45 warnings.log
-rw-r--r-- 1 root root 79 Jul 15 17:45 runtime.yaml
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26$ cd results/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results$ ls -ltr
total 24
drwxr-xr-x 2 root root 4096 Jul 15 17:45 synthesis
drwxr-xr-x 2 root root 4096 Jul 15 17:45 floorplan
drwxr-xr-x 2 root root 4096 Jul 15 17:45 routing
drwxr-xr-x 2 root root 4096 Jul 15 17:45 placement
drwxr-xr-x 2 root root 4096 Jul 15 17:45 cts
drwxr-xr-x 2 root root 4096 Jul 15 17:45 signoff
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results$
```

```
drwxr-xr-x 2 root root 4096 Jul 15 17:45 placement
drwxr-xr-x 2 root root 4096 Jul 15 17:45 cts
drwxr-xr-x 2 root root 4096 Jul 15 17:45 signoff
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results$ cd synthesis/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results/synthesis$ ls
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results/synthesis$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/results$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26$ cd reports/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$ ls -ltr
total 24
drwxr-xr-x 2 root root 4096 Jul 15 17:45 synthesis
drwxr-xr-x 2 root root 4096 Jul 15 17:45 floorplan
drwxr-xr-x 2 root root 4096 Jul 15 17:45 placement
drwxr-xr-x 2 root root 4096 Jul 15 17:45 signoff
drwxr-xr-x 2 root root 4096 Jul 15 17:45 routing
drwxr-xr-x 2 root root 4096 Jul 15 17:45 cts
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$
```

```
5.26/reports/synthesis$ ls
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports/synthesis$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26$ cd reports/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$ ls -ltr
total 24
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 synthesis
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 floorplan
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 placement
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 signoff
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 routing
lrwxr-xr-x 2 root root 4096 Jul 15 17:45 cts
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$ cd synthesis/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports/synthesis$ ls
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports/synthesis$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.4
5.26/reports$
```

```
% run_synthesis
[STEP 1]
[INFO]: Running Synthesis (log: ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis/1-synthesis.log)...
[STEP 2]
[INFO]: Running Single-Corner Static Timing Analysis (log: ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis/2-sta.log)...
%
```

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ cd logs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs$ cd synthesis/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis$ ls -ltr
total 5608
-rw-r--r-- 1 root root 206933 Jul 15 18:15 1-synthesis.log
-rw-r--r-- 1 root root     84 Jul 15 18:15 1-synthesis.warnings
-rw-r--r-- 1 root root     42 Jul 15 18:15 1-synthesis.errors
-rw-r--r-- 1 root root 5520104 Jul 15 18:15 2-sta.log
-rw-r--r-- 1 root root    90 Jul 15 18:15 2-sta.warnings
-rw-r--r-- 1 root root      0 Jul 15 18:15 2-sta.errors
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis$
```

```
16_00.45.26/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26$ cd logs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs$ cd synthesis/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis$ ls -ltr
total 5608
-rw-r--r-- 1 root root 206933 Jul 15 18:15 1-synthesis.log
-rw-r--r-- 1 root root     84 Jul 15 18:15 1-synthesis.warnings
-rw-r--r-- 1 root root     42 Jul 15 18:15 1-synthesis.errors
-rw-r--r-- 1 root root 5520104 Jul 15 18:15 2-sta.log
-rw-r--r-- 1 root root    90 Jul 15 18:15 2-sta.warnings
-rw-r--r-- 1 root root      0 Jul 15 18:15 2-sta.errors
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis$ cd 1-synthesis.log
bash: cd: 1-synthesis.log: Not a directory
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_00.45.26/logs/synthesis$ cat 1-synthesis.log
-----
|   |
|   |   yosys -- Yosys Open SYnthesis Suite
|   |
|
```

```

Number of memories:          0
Number of memory bits:       0
Number of processes:         0
Number of cells:             9819
$_ANDNOT_                   1159
$_AND_                        399
$_MUX_                        4412
$_NAND_                       226
$_NOR_                        175
$_NOT_                        144
$_ORNODT_                     165
$_OR_                          1042
$_XNOR_                       113
$_XOR_                        388
sky130_fd_sc_hd__dfxtp_2    1596

[INFO]: USING STRATEGY AREA 0
[INFO]:          1888 1888 4096 4096 301 14 34 34 dependencies
[INFO]:          1888 1888 4096 4096 301 14 34 34 very
[INFO]:          1888 1888 4096 4096 301 14 34 34 install

```

## Chip Floor Planning Considerations

### Utilization Factor and Aspect Ratio

- ❖ 1. Define width and height of core and die – begin with netlist (connectivity of an electronic design), use dimensions of standard cell to find area occupied on wafer,
- ❖ Utilization factor = area occupied by netlist/ area occupied by core
- ❖ Aspect ratio = height/width

### Concept of pre-placed cells

- ❖ 2. Define locations of preplaced cells –
- ❖ Preplaced cells are logic blocks that can be reused, ex: memory, comparator, mux etc.
- ❖ The arrangement of these is called floor planning
- ❖ They have user defined locations so they are put before automated planning and routing (that's why called pre-placed)

### De-coupling capacitors

- ❖ Surround pre-placed cells with decoupling capacitors
- ❖ Vdd' (voltage after going through resistance which reaches logic) needs to be within noise margin to be stable

- ❖ Decoupling capacitors solve earlier problem as their voltage is same as main supply and pre-placed cells get voltage from these capacitors.

## Power Planning

- ❖ Lots of power sources to solve problem of ground bounce and voltage droop

## Pin placement and logical cell placement blockage

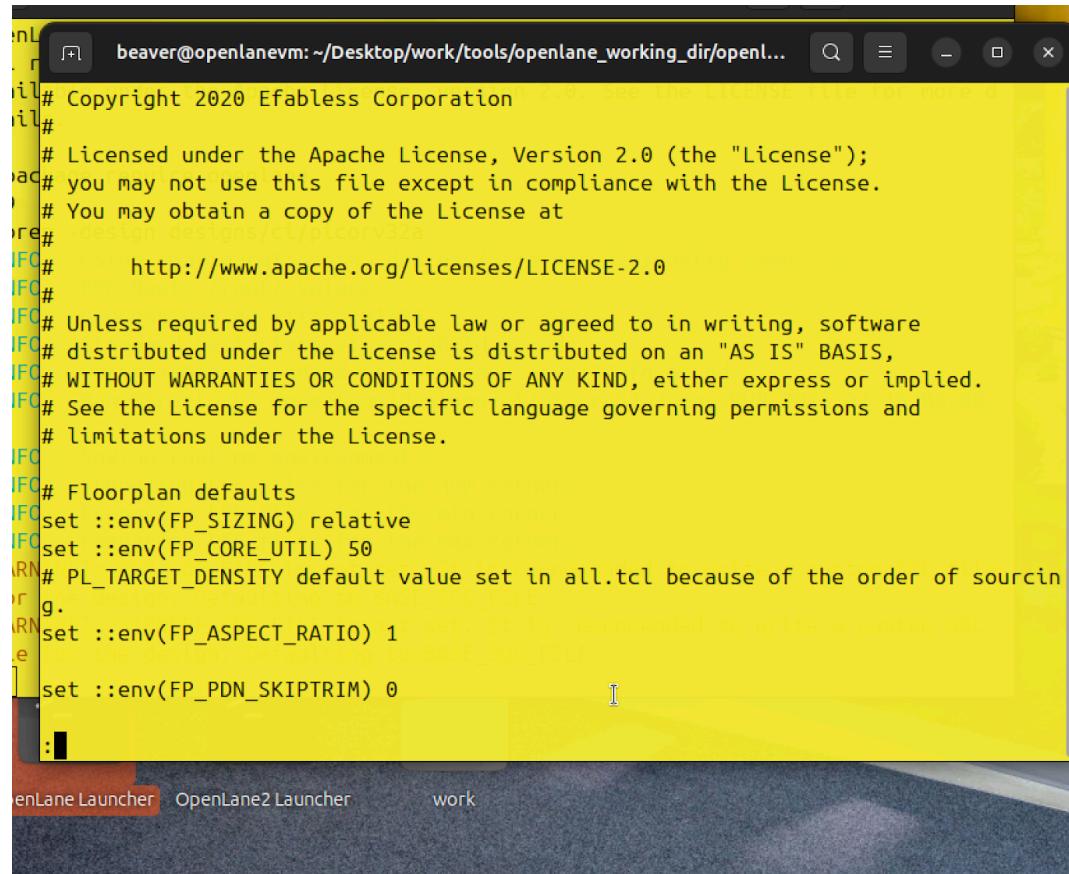
- ❖ The connectivity info between gates is coded using VDHL/Verilog and is called as “netlist”
- ❖ Clock ports are larger than data ports, least resistance needs to be with clocks since they are continuously driving cells, size is inversely proportional to resistance
- ❖ After pin placement (input, output), create Logical Cell Placement Blockage so APR doesn't put any cells on pin location

## Steps to run floorplan on openLANE

- ❖ Cd into configuration

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd picorv32a/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ cd ../..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd configuration/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd configuration$ ls -ltr
total 36
-rwxrwxr-x 1 beaver beaver 1261 Jul 14 07:34 synthesis.tcl
-rwxrwxr-x 1 beaver beaver 2109 Jul 14 07:34 routing.tcl
-rwxrwxr-x 1 beaver beaver 1672 Jul 14 07:34 placement.tcl
-rw-rw-r-- 1 beaver beaver 101 Jul 14 07:34 load_order.txt
-rwxrwxr-x 1 beaver beaver 2408 Jul 14 07:34 general.tcl
-rwxrwxr-x 1 beaver beaver 1591 Jul 14 07:34 floorplan.tcl
-rw-rw-r-- 1 beaver beaver 687 Jul 14 07:34 extraction.tcl
-rwxrwxr-x 1 beaver beaver 921 Jul 14 07:34 cts.tcl
-rwxrwxr-x 1 beaver beaver 1173 Jul 14 07:34 checkers.tcl
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ configuration$
```

❖ Less floorplan.tcl



```
# Copyright 2020 Efabless Corporation
#
# Licensed under the Apache License, Version 2.0 (the "License");
# you may not use this file except in compliance with the License.
# You may obtain a copy of the License at
#
#     http://www.apache.org/licenses/LICENSE-2.0
#
# Unless required by applicable law or agreed to in writing, software
# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
# See the License for the specific language governing permissions and
# limitations under the License.

# Floorplan defaults
set ::env(FP_SIZING) relative
set ::env(FP_CORE_UTIL) 50
# PL_TARGET_DENSITY default value set in all.tcl because of the order of sourcing.
set ::env(FP_ASPECT_RATIO) 1
set ::env(FP_PDN_SKIPTRIM) 0
```

❖ q to exit

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/configurations$ cd ..
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs$ cd ci
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd picorv32a/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ pwd
/home/beaver/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ ls -ltr
total 12
drwxrwxr-x 2 beaver beaver 4096 Jul 15 16:44 src
-rw-rw-r-- 1 beaver beaver 487 Jul 15 16:44 config.json
drwxr-xr-x 7 root root 4096 Jul 15 20:09 runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$
```



config.json launched

beaver@openlanevm:~/Desktop/work/tools/openlane\_working\_dir/openlane/configurations\$

beaver@openlanevm:~/Desktop/work/tools/openlane\_working\_dir/openlane/configurations\$



Less config.json

```
beaver@openlanevm: ~/Desktop/work/tools/openlane_working_dir/openl... | Q | ⌂ | - | □ | × |
```

```
eave
cd .
eave
..
eave< openlanevm:~/Desktop/work/tools/openlane_working_dir/openLane> cd ..config
eave{ openlanevm:~/Desktop/work/tools/openLane_working_dir/openLane/config>
n$ l      "DESIGN_NAME": "picorv32",
otal      "VERILOG_FILES": "dir::src/picorv32a.v",
rwxr      "CLOCK_PORT": "clk",
rwxr      "CLOCK_NET": "clk",
rwxr      "GLB_RESIZER_TIMING_OPTIMIZATIONS": true,
rwxr      "RUN_HEURISTIC_DIODE_INSERTION": true,
rwxr      "DIODE_ON_PORTS": "in",
rwxr      "GPL_CELL_PADDING": 2,
rwxr      "DPL_CELL_PADDING": 2,
rwxr      "CLOCK_PERIOD": 24,
rwxr      "FP_CORE_UTIL": 35,
eave      "pdk::sky130*": {
n$ l          "MAX_FANOUT_CONSTRAINT": 6,
eave        "scl::sky130_fd_sc_ms": {
n$ l            "FP_CORE_UTIL": 30
eave      }
n$ l    }
ne La} config.json (END)
```

- ❖ Q to exit
- ❖ IMPORTANT: vertical/horizontal metals is set to one more than what we say

```
OpenLane e0d2e618a8834e733d28dfcc02fa166941be7e71
All rights reserved. (c) 2020-2023 Efabless Corporation and contributors.
Available under the Apache License, version 2.0. See the LICENSE file for more details.

% package require openlane
0.9
% prep -design designs/ci/picorv32a
[INFO]: Using configuration in 'designs/ci/picorv32a/config.json'...
[INFO]: PDK Root: /root/.volare
[INFO]: Process Design Kit: sky130A
[INFO]: Standard Cell Library: sky130_fd_sc_hd
[INFO]: Optimization Standard Cell Library: sky130_fd_sc_hd
[INFO]: Run Directory: /openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_03.09.01
[INFO]: Saving runtime environment...
[INFO]: Preparing LEF files for the nom corner...
[INFO]: Preparing LEF files for the min corner...
[INFO]: Preparing LEF files for the max corner...
[WARNING]: PNR_SDC_FILE is not set. It is recommended to write a custom SDC file for the design. Defaulting to BASE_SDC_FILE
[WARNING]: SIGNOFF_SDC_FILE is not set. It is recommended to write a custom SDC file for the design. Defaulting to BASE_SDC_FILE
%
◆ beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/de
```

- run\_floorplan (make sure to have run\_synthesis before run\_floorplan)

```
file for the design. Defaulting to BASE_SDC_FILE
6 run_synthesis
[STEP 1]
[INFO]: Running Synthesis (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/synthesis/1-synthesis.log)...
[STEP 2]
[INFO]: Running Single-Corner Static Timing Analysis (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/synthesis/2-sta.log)...
6 run_floorplan
[STEP 3]
[INFO]: Running Initial Floorplanning (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan/3-initial_fp.log)...
[INFO]: Floorplanned with width 530.84 and height 530.4.
[STEP 4]
[INFO]: Running IO Placement (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan/4-io.log)...
[STEP 5]
[INFO]: Running Tap/Decap Insertion (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan/5-tap.log)...
[INFO]: Power planning with power {VPWR} and ground {VGND}...
[STEP 6]
[INFO]: Generating PDN (log: designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan/6-pdn.log)...
6
```

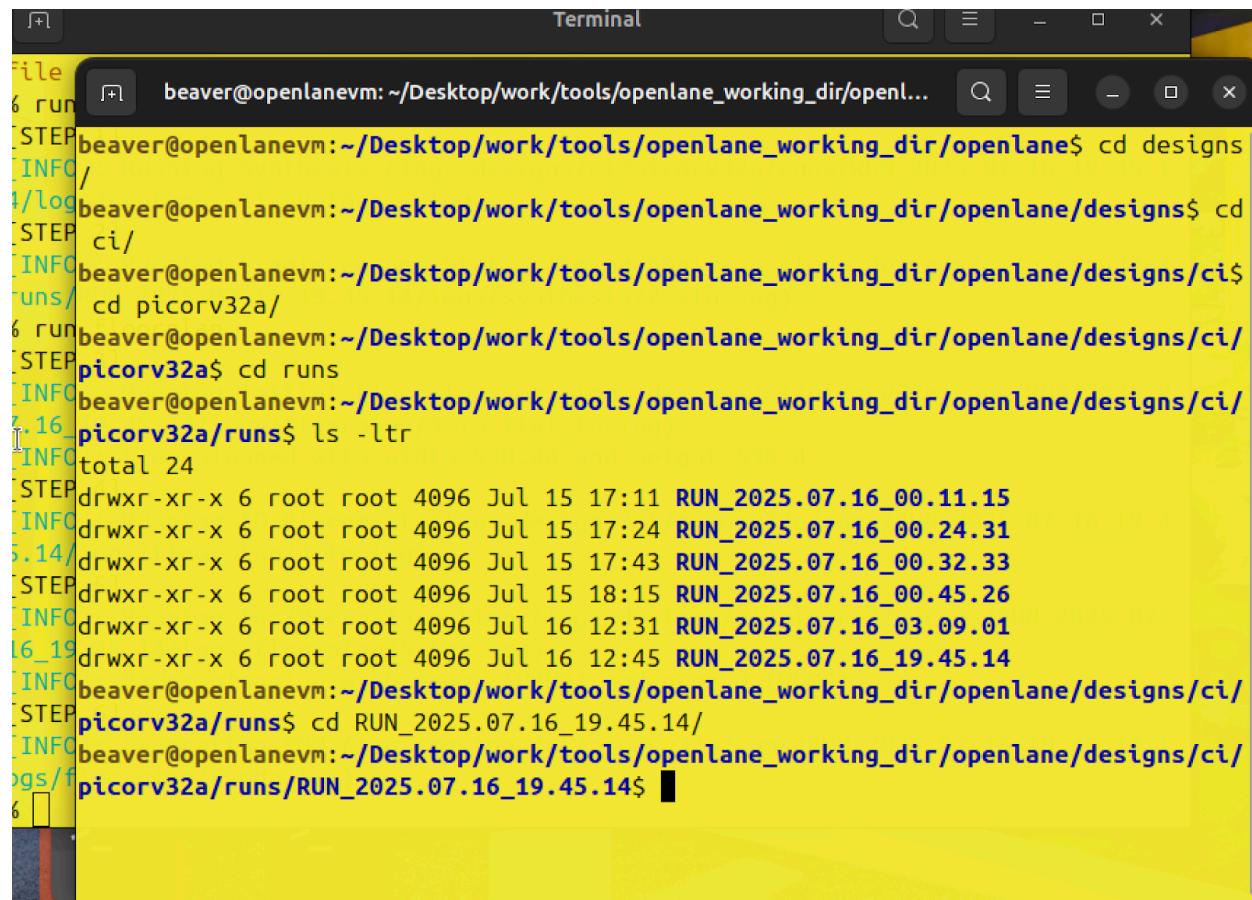
- ❖ Go to runs folder on other tab (cd runs)

The screenshot shows a Linux desktop environment with a terminal window open. The terminal window has a dark theme and displays a command-line session. The session starts with a file browser window in the foreground, showing a file named 'file' with a size of 1.4M. The terminal window title bar says 'Terminal'. The terminal command history is as follows:

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs  
[INFO]  
4/log  
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs/  
[INFO]  
ci/  
[INFO]  
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd picorv32a/  
% run  
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ cd runs  
[INFO]  
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs$ [REPLACEMENT CHARACTER]
```

The terminal window has a dark background and light-colored text. The file browser window behind it has a light background and dark text. The overall interface is clean and modern.

❖ Ls -ltr and cd into latest run



```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane$ cd designs/ci/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci$ cd picorv32a/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a$ cd runs
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs$ ls -ltr
total 24
drwxr-xr-x 6 root root 4096 Jul 15 17:11 RUN_2025.07.16_00.11.15
drwxr-xr-x 6 root root 4096 Jul 15 17:24 RUN_2025.07.16_00.24.31
drwxr-xr-x 6 root root 4096 Jul 15 17:43 RUN_2025.07.16_00.32.33
drwxr-xr-x 6 root root 4096 Jul 15 18:15 RUN_2025.07.16_00.45.26
drwxr-xr-x 6 root root 4096 Jul 16 12:31 RUN_2025.07.16_03.09.01
drwxr-xr-x 6 root root 4096 Jul 16 12:45 RUN_2025.07.16_19.45.14
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs$ cd RUN_2025.07.16_19.45.14/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14$
```

❖ ls -ltr again and cd in logs/floorplan

```
file
% run
[STEP] drwxr-xr-x 6 root root 4096 Jul 15 18:15 RUN_2025.07.16_00.45.26
[INFO] drwxr-xr-x 6 root root 4096 Jul 16 12:31 RUN_2025.07.16_03.09.01
4/lo drwxr-xr-x 6 root root 4096 Jul 16 12:45 RUN_2025.07.16_19.45.14
[STEP] beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/
[INFO] picorv32a/runs$ cd RUN_2025.07.16_19.45.14/
runs/ beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/
% run picorv32a/runs/RUN_2025.07.16_19.45.14$ ls -ltr
[STEP] total 68
[INFO] -rw-r--r-- 1 root root 51 Jul 14 07:39 PDK_SOURCES
7.16 -rw-r--r-- 1 root root 674 Jul 16 12:45 config_in.tcl
[INFO] drwxr-xr-x 8 root root 4096 Jul 16 12:45 results
[STEP] drwxr-xr-x 8 root root 4096 Jul 16 12:45 reports
[INFO] drwxr-xr-x 8 root root 4096 Jul 16 12:45 logs
5.14 -rw-r--r-- 1 root root 50 Jul 16 12:45 OPENLANE_VERSION
[STEP] -rw-r--r-- 1 root root 254 Jul 16 12:45 warnings.log
[INFO] 16_19 drwxr-xr-x 8 root root 4096 Jul 16 12:45 tmp
16_19 -rw-r--r-- 1 root root 1371 Jul 16 12:45 openlane.log
[INFO] [STEP] -rw-r--r-- 1 root root 7636 Jul 16 12:45 cmds.log
[INFO] -rw-r--r-- 1 root root 572 Jul 16 12:45 runtime.yaml
[INFO] -rw-r--r-- 1 root root 18862 Jul 16 12:45 config.tcl
logs/ f beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/
% logs/floorplan/ picorv32a/runs/RUN_2025.07.16_19.45.14$ cd logs/floorplan/
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/
picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan$
```

❖ ls -ltr and than less 4-io.log

The screenshot shows a terminal window titled "Terminal" with the command "beaver@openlanenvm: ~/Desktop/work/tools/openlane\_working\_dir/openlane\$". The terminal displays a series of log entries from a build process. The logs include file permissions, modification times, and file names such as "tmp", "openlane.log", "cmds.log", "runtime.yaml", "config.tcl", and various log files for steps like initial\_fp, 5-tap, and 6-pdn. The user then runs "ls -ltr" to list the files in the current directory, which includes "4-io.log". Finally, the user runs "less 4-io.log" to view the contents of the 4-io.log file.

```
drwxr-xr-x 8 root root 4096 Jul 16 12:45 tmp
-rw-r--r-- 1 root root 1371 Jul 16 12:45 openlane.log
-rw-r--r-- 1 root root 7636 Jul 16 12:45 cmds.log
-rw-r--r-- 1 root root 572 Jul 16 12:45 runtime.yaml
-rw-r--r-- 1 root root 18862 Jul 16 12:45 config.tcl
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14$ cd logs/floorplan/
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan$ ls -ltr
total 16
-rw-r--r-- 1 root root 2206 Jul 16 12:45 3-initial_fp.log
-rw-r--r-- 1 root root 0 Jul 16 12:45 3-initial_fp.warnings
-rw-r--r-- 1 root root 0 Jul 16 12:45 3-initial_fp.errors
-rw-r--r-- 1 root root 1739 Jul 16 12:45 4-io.log
-rw-r--r-- 1 root root 0 Jul 16 12:45 4-io.warnings
-rw-r--r-- 1 root root 0 Jul 16 12:45 4-io.errors
-rw-r--r-- 1 root root 1372 Jul 16 12:45 5-tap.log
-rw-r--r-- 1 root root 0 Jul 16 12:45 5-tap.warnings
-rw-r--r-- 1 root root 0 Jul 16 12:45 5-tap.errors
-rw-r--r-- 1 root root 1510 Jul 16 12:45 6-pdn.log
-rw-r--r-- 1 root root 0 Jul 16 12:45 6-pdn.warnings
-rw-r--r-- 1 root root 0 Jul 16 12:45 6-pdn.errors
beaver@openlanenvm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan$ less 4-io.log
```

OpenLane Launcher OpenLane2 Launcher work

```
file
% run
[STEP] Using 1e-09 for power...
[INFO] Using 1e-06 for distance...
4/logReading design constraints file at '/openlane/scripts/base.sdc'...
[STEP][INFO]: Setting output delay to: 4.800000000000001
[INFO]: Setting input delay to: 4.800000000000001
runs/[INFO]: Setting load to: 0.033442
% run[INFO]: Setting clock uncertainty to: 0.25
[STEP][INFO]: Setting clock transition to: 0.15
[INFO][INFO]: Setting timing derate to: 5.0 %
7.16Found 0 macro blocks.
[INFO][INFO PPL-0010] Tentative 0 to set up sections.
[STEP][INFO PPL-0001] Number of slots          664
[INFO][INFO PPL-0002] Number of I/O           409
5.14/[INFO PPL-0003] Number of I/O w/sink    342
[STEP][INFO PPL-0004] Number of I/O w/o sink  67
[INFO][INFO PPL-0005] Slots per section      200
16_19[INFO PPL-0006] Slots increase factor   0.01
[INFO][INFO PPL-0008] Successfully assigned pins to sections.
[STEP][INFO PPL-0012] I/O nets HPWL: 138196.58 um.
[INFO]Writing OpenROAD database to '/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/tmp/floorplan/4-io.odb'...
ogs/f[INFO]Writing layout to '/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/tmp/floorplan/4-io.def'...
% [END]
```

- ❖ Q to exit , shift g for end
- ❖ Cd .. twice and ls -ltr and then less config.tcl

```
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14/logs/floorplan$ cd ../../
beaver@openlanevm:~/Desktop/work/tools/openlane_working_dir/openlane/designs/ci/picorv32a/runs/RUN_2025.07.16_19.45.14$ less config.tcl
```